New data on the Permian crinoid family Calceolispongiidae in Western Australia

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Abstract

Previously published data on the geographic distribution and stratigraphic range of members of the crinoid family Calceolispongiidae in the Permian of Western Australia are updated and a census of all recorded occurrences of Western Australian species, named as well as unnamed, is taken. Representatives of the family are found throughout a maximum thickness of approximately 2 300 m of sedimentary rocks, ranging in age through the entire Early Permian. The family contains at least three genera, only two of which have been named. Total number of species seems to be in the vicinity of 30, of which 15 have been named and described.

Introduction

In 1949, I published a monographic treatment of all then known Western Australian species of a highly unusual Permian crinoid genus, *Calceolispongia*. This monograph was based mostly on material collected by me and students on numerous field trips to the northern part of the Perth Basin, to various parts of the Carnarvon Basin, and to the Canning Basin, carried out from 1938 until mid-1941. My investigations were made at a time when no topographic maps of these areas existed and before a code of stratigraphic nomenclature was introduced in Australia. Consequently, localities had to be identified with reference to local landmarks in areas where named geographic features were few. The unexpectedly great thickness of Permian rocks, especially in the Carnarvon Basin, made it necessary to name numerous rock units, previously unrecognized, and for this purpose I fell back on the somewhat antiquated stratigraphic terminology then in use in Australia. Thus, I used the term "stage" for rock units for which the use of "formation" is now mandatory, the term "series" for what is now "group," and I used fossil names for rock units (e.g., *"Calceolispongia* stage" for what I later named Wandagee Formation). The first version of an Australian Code of Stratigraphic Nomenclature was not published until 1948 (Glaessner *et al.* 1948), and the first attempt at modernizing the nomenclature of some of the Permian rock units in Western Australia was not made until 1950 (Teichert 1950).

Now, detailed topographical and geological maps of many areas studied by me in the distant past are available, thanks largely to the efforts of the Bureau of Mineral Resources, Geology and Geophysics and the Geological Survey of Western Australia, and most of the stratigraphic nomenclature in the sedimentary basins has been formalized to meet the requirements of the Australian Code of Stratigraphic Nomenclature (Teichert, 1950; Condon 1967; van de Graaff *et al.* 1977; Hocking *et al.*1980; Hocking 1985, 1988). It is, therefore, now possible to update and refine both geographical and stratigraphical occurrence data for most of the species described by me in 1949 and it is the purpose of this communication to supply this kind of information. The vertical range of most species of *Calceolispongia* is rather restricted. In the classical stratigraphic section along the Minilya River on Wandagee Station (see Teichert 1949, fig. 13) species follow each other in stratigraphic succession, most of them being restricted to beds only a few tens of metres, or less, thick. Most species of *Calceolispongia* thus fulfill the conditions for good index fossils.

In my monograph in 1949, I expressed hope that it "will furnish a useful basis for additional and more detailed work when the geographic distribution and earlier geologic history of *Calceolispongia* are better known." Alas, this hope has not been fulfilled. In 1954, I described a new genus, *Jimbacrinus*, from the Carnarvon Basin and proposed the family Calceolispongiidae to include this genus, together with *Calceolispongia*. In 1979, Willinck described a number of species of *Calceolispongia* from Queensland, New South Wales, and Tasmania, none of them identical with any Western Australian species. In fact, after 1954 no further addition to the taxonomy of the Calceolispongiidae in Western Australia was made until 1987, when Webster redescribed two species of *Calceolispongia* from the Callytharra Formation and added one indeterminate species from the same formation. In 1990, Webster described a new species of *Jimbacrinus* from the Wandagee Formation.

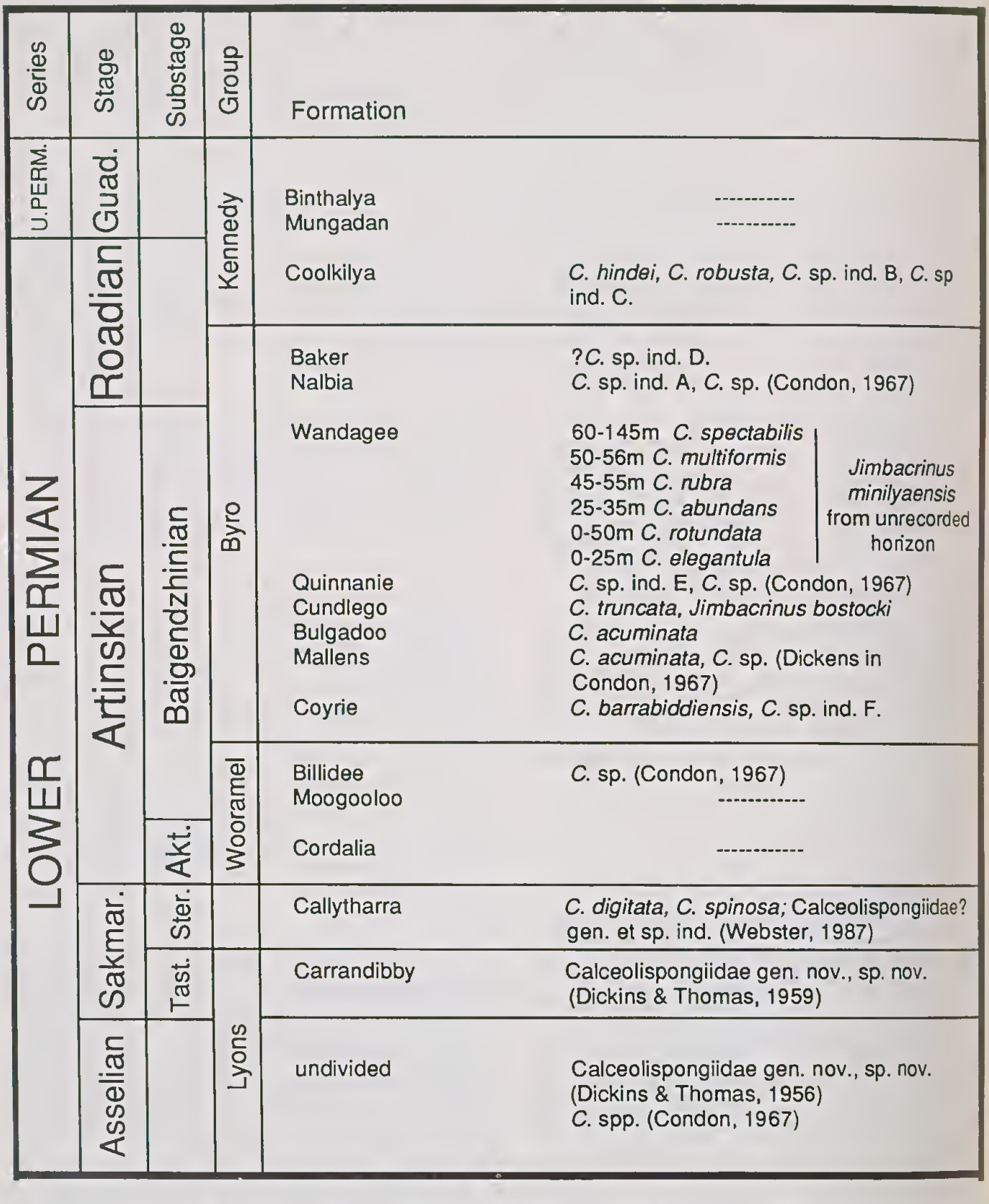

Figure 1 Distribution of Calceolispongiidae in the Permian strata of the Carnarvon Basin. (C = *Calceolispongia*, Akt. = Aktastian, Guad. = Guadalupian, Ster. = Sterlitamakian, Tast. = Tastubian).

Meanwhile, Guppy *et al.* (1950), Dickins and Thomas (1956, 1959), Condon (1967), and Dickins *et al.* (1977) had recorded numerous occurrences of Calceolispongiidae, including at least one new genus, from new localities in the Carnarvon and Canning Basins and extended the stratigraphic range of the family downward into the Lyons Group. Unfortunately, most of these species remained undescribed and unnamed. In order to make the updating of information on the Calceolispongiidae as complete as possible, I have culled all the information from the published literature to present a new and improved picture of the stratigraphic distribution of the family in the Permian rocks of Western Australia, including many unnamed species and, possibly, genera.

In the following are listed all occurrences of Calceolispongiidae presently recorded in print from Western Australia. No descriptions or discussions are supplied for species that have already been adequately described and discussed in easily accessible publications (Teichert 1949, 1954; Webster 1987, 1990).

Stratigraphic Distribution of the Calceolispongiidae in Western Australia

The maximum thickness of Permian rocks in the Carnarvon Basin is about 3 500 m, but this figure is probably reached only in the northern half of the basin; here, most of the recorded species of Calceolispongiidae occur throughout the lowermost 2 300 m of the Permian section. The vertical distribution of species, named and unnamed, of the calceolispongiids, including at least one unnamed new genus, is shown on Figure 1. The stage correlation is that proposed by Glenister *et al.* (1985). Rather unexpectedly, the family makes its first appearance in the Lyons Group which is of glacigene origin. Condon (1967) divided the Lyons Group into seven formations, from four of which he reported presence of unnamed species of Calceolispongiidae. However, van de Graaff *et al.* (1977) were unable to map these formations on the ground; they proposed to reduce the rank of the Lyons Group to that of Formation, reducing Condon's seven formations to the status of local members. Hocking (1985), on the other hand, reinstated the Lyons as a Group, including in it as basal unit the Harris Sandstone of Carboniferous age (not shown in Figure 1) and as top unit the Carrandibby Formation. He regarded the bulk of the Lyons Group above the Harris Sandstone as being Early Permian (Sakmarian) in age.

Although the relative stratigraphic position of the various species of Calceolispongiidae in the Lyons Group is not know, it is interesting to note the environments in which they lived. An unnamed species of *Calceolispongia* is mentioned from the "Dumbaro siltstone" which Condon (1967, p. 26) described as having been deposited "in water from floating ice derived from continental glaciers or a continental ice sheet." Another species of *Calceolispongia* is reported from the "Mundarie siltstone" which, according to Condon (1967, p. 43), was deposited in "fairly deep water directly from icebergs derived from continental ice-sheet." Condon (1967) listed a "Calceolispongiidae,spec. nov." from the "Thambrong formation" which he described (1967, p. 49) as having formed during a "period of rapid fluctuation of icesheet advance and retreat, with the tillitic siltstone and greywacke deposited during periods of advance and the fluvioglacial quartzwacke and varves during period of retreat." Unfortunately, it is not recorded in which of these facies the calceolispongiid occurs.

The last occurrence of this family in the Lyons Group is in the Carrandibby Formation which Condon (1967) regarded as post-Lyons, but which Playford et al. (1975) and Hocking (1985) regarded as a formation at the top of the Lyons Group in the northern Carnarvon Basin. This species is said by Dickins and Thomas (1959) to be similar to one recorded from marine Permian beds in Umaria, India (see Teichert 1949 pl. 25, figs. 19-22). An unnamed calceolispongiid from the top of the Grant Group of the Canning Basin ("Calceolispongid gen. et spec. nov." of Dickins and Shah 1977) probably represents the same, or a closely related, genus. Regrettably, none of this material has ever been studied in detail. This is another glaring example of an "unpublished fossil record" to which Teichert *et al.* (1987) called attention: important fossil materials that rest for decades unattended, often poorly curated, in museums and research collections all over the world. The calceolispongiids from the Lyons Group were collected in the late 1940s and early 1950s, mostly by geologists of the Bureau of Mineral Resources, Geology and Geophysics, and, during the last 40 years, have joined untold numbers of fossils awaiting study and description in the museums of the world.

Calceolispongia is a most unusual and distinct genus of crinoids that became first known as a prolific member of the Artinskian warm-water faunas of Timor (as *Dimocrinus* Wanner 1916) and Western Australia (Teichert 1949). It now seems that the family Calceolispongiidae originated among Asselian cold-water faunas of the Lyons Group in the Carnarvon Basin and the Grant Group in the Canning Basin. It would be of considerable interest to learn how the changeover from a cold-water to a warm-water environment affected the evolution of this family.

The Callytharra Formation rests with a strong disconformity on the rocks of the Lyons Group. It has yielded the two smallest species of *Calceolispongia* known so far. The virtual absence of the genus from rocks of the Wooramel Group may be due to facies changes, because the rocks of this group are described as predominantly arenaceous (Condon 1967). No significant additions have been made to the knowledge of Calceolispongiidae in the Byro and Kennedy Groups since publication of my monographic description (Teichert 1949).

Outside the Carnarvon Basin, calceolispongiids are, in Western Australia, known from the Perth and Canning Basins, where they are much more restricted stratigraphically. The Fossil Cliff Member of the Holmwood Shale in the Perth Basin has yielded only *Calceolispongia digitata*, one of the two small species of the Callytharra Formation of the Carnarvon Basin. In the Canning Basin, only the Noonkanbah Formation and the Grant Group have yielded calceolispongiids, most of them recorded without adequate locality and stratigraphic data. They are: *Calceolispongia hindei*, *C. rotundata*, *C. rubra*, *C. spectabilis*, and *C.* sp. ind. of Guppy *et al.* (1950), in the Noonkanbah Formation; an undescribed species, probably representing a new genus, in the Grant Formation. The Noonkanbah Formation is generally regarded as the equivalent of the Byro Group of the Carnarvon Basin (see Playford et al. 1975), but from the composition of its *Calceolispongia* fauna

it is clear that it represents no more than the equivalents of the Wandagee Formation and perhaps some of the Coolkilya Formation. The unidentified calceolispongiid in the Grant Group was found near the top of this unit and is of early Sakmarian age.

Palaeontology

Phylum Echinodermata

Subphylum Crinozoa Matsumoto, 1929

Class Crinoidea Miller, 1821

Subclass Inadunata Wachsmuth & Springer, 1885

Order Cladida Moore & Laudon, 1943

Suborder Poteriocrinina Jaekel, 1918

Superfamily Calceolispongiacea Teichert, 1954

Cup large to small, base concave to flat, distinguished mainly by prominent spine- or spade-like projects of basals in most species, arms five, obliqui-uniserial (Lane in Moore & Teichert 1978, p. 754).

Remarks: The family Calceolispongiidae Teichert (1954) was upgraded to superfamily status by Moore, Lane, and Strimple (in Moore & Strimple 1973). After discovery of species of *Calceolispongia* that show no significant thickening of the basals, Willink (1979) suspected that this family might just be a specialized end branch of the Texacrinacea Strimple.

Range and Distribution: Lower Permian: Australia (Western Australia, Queensland, New South Wales, Tasmania), Indonesia (Timor), India (Punjab Himalaya, Umaria). Upper Permian: Australia (Queensland, New South Wales).

Family Calceolispongiidae Teichert, 1954

Cup large, bowl-shaped, with shallow basal invagination; infrabasals small, concealed by stem, not visible from side; basals large, in most species spinose or tuberculate; radial arm facets wide, inclined outward-upward; one anal plate in cup, separating radials. Arms uniserial, unbranched, pinnulate. Stem small, relative to cup size (Lane in Moore & Teichert, 1978, p. 755).

Range and distribution: as for superfamily.

Remarks: In a discussion of the genus *Jimbacrinus*, Yakovlev (1964, p. 109-111) dismisses the features of the *skulptura* (sculpture) of the cup plates as taxonomically unimportant and states that this genus and *Calceolispongia* should not have been placed in a new family. However, he does not cite my 1949 monograph and does not discuss *Calceolispongia*. The Calceolispongiidae, as well as the Calceolispongiacea, were retained in the *Treatise on Invertebrate Paleontology* (Lane in Moore & Teichert 1978) and also by Willink (1979).

Calceolispongia Etheridge, 1915

(Synonym: *Dinocrinus* Wanner, 1916)

Type species: *Calceolispongia hindei* Etheridge, 1915.

Cup large to small, bowl-shaped, with very shallow to deep basal concavity and indented basal-radial sutures; infrabasals small, diamond-shaped, not visible or barely visible from side; basals hexagonal except for CD basal which is truncated by anal X; basals greatly thickened and expanded into large, hornlike, or spade-shaped projections, or unthickened and ornamented by tubercules or spines; radials pentagonal, shorter than basals, separated by anal X in CD interray; radial arm facets occupying full width of plates, inclined outward and upward, muscle area long. Arms unbranched, uniserial, pinnulate, coiling; proximal 2 brachials large and trapezoidal, distal brachials cuneiform. Brachial articulations predominantly muscular. Stem small, relative to cup size, circular in section, having long, slender cirri (very slightly modified after Willink 1979, p. 164).

Range and distribution: Lower Permian: Australia (Western Australia, Queensland, New South Wales), Indonesia (Timor), India (Punjab Himalaya, Umaria, though possibly a new genus). Upper Permian: Australia (Queensland, New South Wales).

Calceolispongia abundans Teichert

1949 *Calceolispongia abundans* Teichert, p. 54-59, pl. 1, figs., 2, 7, 12, 21; pl. 6, figs. 21, 22; pl. 8, fig. 2; pl. 9; pl. 10; pl. 11; pl. 12.

Types: Holotype: Western Australian Museum G. 8501; topotypes: UWA[1] 22245-22257, 22276, 22278-22281; Western Australian Museum 8430, 8433, 8440-8442, 8484, 8485, 8666-8742, 17044.

Geographic distribution: Type locality in syncline with axis 1.3 km west of Coolkilya Pool, Minilya River, Wandagee Station, Carnarvon Basin. Distribution elsewhere poorly known.

Stratigraphic range: 25 to 35 m above base of Wandagee Formation, Byro Group.

Age: Early Permian (Artinskian, late Baigendzhinian).

Calceolispongia acuminata Teichert

1949 *Calceolispongia acuminata* Teichert, p. 59-60, plate 5, figs. 8-35.

Types: Holotype UWA 21538; topotypes and other material 21539-21543; also in Commonwealth Paleontological Collections, Canberra.

Geographic distribution: Type material is from the south bank of the Minilya River, near Bulgadoo Pool, about 5 km northwest of Wandagee Homestead, Wandagee Station, Carnarvon Basin. Other localities are the south bank of Barrabiddy Creek, about 550 m west of the junction of Quail Quail Creek, Wandagee Station, and in outcrops to the south and east of Bogadi Outcamp, Byro Station, Carnarvon Basin.

Stratigraphic range: Uppermost part of Bulgadoo Shale, Byro Group, but exact range not known. Doubtfully listed from unspecified horizon of the Mallens Formation in the southern Carnarvon Basin (Dickins in Condon 1967).

Age: Early Permian (Artinskian, early Baigendzhinian).

[1] UWA = Geology Department, University of Western Australia

Calceolispongia barrabiddiensis Teichert

1949 *Calceolispongia barrabiddiensis* Teichert, p. 60-61, pl. 3, figs. 1-7.

Types: Holotype UWA 21523; paratypes UWA 21521, 21524.

Geographic distribution: On east limb of Barrabiddy anticline, outcrops 400 to 800 m south of Barrabiddy Dam, Wandagee Station, Carnarvon Basin.

Stratigraphic Range: Shale of the Coyrie Formation (see Condon 1967 p. 131), associated with *Pseudoschistoceras simile* Teichert.

Age: Early Permian (Artinskian, early Baigendzhinian).

Calceolispongia digitata Teichert

1949 *Calceolispongia digitata* Teichert, p. 61-63, p. 2, figs. 1-15.

Types: Holotype UWA 21526; topotypes UWA 21517-21530.

Geographic distribution: Type material from about 800 m west of Callytharra Spring on One Gum Creek, 450 m upstream from its junction with the Wooramel River, Carnarvon Basin; also recorded from Fossil Cliff, on the north branch of the Irwin River, about 1.2 km upstream from its junction with the south branch, northern part of Perth Basin (Clarke et al. 1951).

Stratigraphic range: Callytharra Formation, Carnarvon Basin; Fossil Cliff Member of the Holmwood Shale, Perth Basin.

Age: Early Permian (latest Sakmarian, Sterlitamakian).

Calceolispongia elegantula Teichert

1949 *Calceolispongia elegantula* Teichert, p. 63-71, pl. 1, figs. 1, 8, 13; pl. 5, figs. 14-16; pl. 6, figs. 1-20, 23-80; pl. 8, fig. 1.

Types: Holotype UWA 22060a; topotypes UWA 22060-22077, 22078-22082, 22084-22097, 22099-22103, 22105.

Geographic Distribution: On both banks of Minilya River in N-S syncline with axis 1.3 km west of Coolkilya Pool, Minilya River, Wandagee Station, Carnarvon Basin; several localities in Mungadan and Nalbia Paddocks, Wandagee Station.

Stratigraphic range: Lowermost 25 m of Wandagee Formation, Byro Group.

Age: Early Permian (Artinskian, late Baigendzhinian).

Calceolispongia hindei Etheridge

1915 *Calceolispongia hindei* Etheridge, Jr., 1915, p. 9-13, pl. 4, figs. 1-9; pl. 7, figs. 5, 6.

Types: Lectotype 10930-1 Geological Survey of Western Australia; 4 paratypes in same collection; topotypes UAW 21465-21468, 20773, 20774.

Geographic distribution: Type locality southeast corner of Mount Marmion, close to the foot of the slope, Kimberley Downs Station, Canning Basin; also 2 localities on Wandagee Station, Carnarvon Basin.

Stratigraphic range: Near top of Noonkanbah Formation in Canning Basin; lowest beds of Coolkilya Sandstone in Carnarvon Basin.

Age: Early Permian (Roadian).

Calceolispongia multiformis Teichert

1949 *Calceolispongia multiformis* Teichert, p. 75-80, pl. 1, figs. 3, 5, 6, 10, 11, 14, 15, 17, 18, 23, 24; pl. 14; pl. 16.

Geographic distribution: Type locality in N-S syncline on Minilya River with axis 1.3 km west of Coolkilya Pool, Minilya River, Wandagee Station, Carnarvon Basin; also from a few additional localities on Wandagee Station; doubtfully identified from an unspecified locality in Noonkanbah Formation, Canning Basin; also reported from Chimlo-da-Fali and Tramavala in the Chamba synclinorium of the Punjab Himalaya, India (Kapoor 1973).

Stratigraphic range: 50-56 m above base of Wandagee Formation, Byro Group; indeterminate horizon in Noonkanbah Formation, Canning Basin; Tramavala Formation, Bhallesh Group, in the Punjab Himalaya.

Age: In Australia, Early Permian (Artinskian, late Baigendzhinian); in India, "earliest Permian" (Kapoor 1973).

Calceolispongia robusta Teichert

1949 *Calceolispongia robusta* Teichert, p. 80-83, pl. 24.

Types: Holotype UWA 21476; paratype UWA 21469.

Geographic distribution: Near SE corner of Wandagee Hill, about 800 m on N145°E of SE corner of Shed Paddock, Wandagee Station, Carnarvon Basin (for further details see Teichert 1949 p. 82).

Stratigraphic range: Coolkilya Sandstone, Kennedy Group. [Exact position in Coolkilya Sandstone unknown; the vertical range of probably 900 feet (275 m) given by Teichert (1949, p. 82) is certainly wrong, because the thickness of the formation around Wandagee Hill is stated to be only about 700 feet (213 m) (Condon 1967, p. 183). On the basis of data supplied by Dickins (1963, p. 147) the highest occurrence seems to be in the middle part of the Coolkilya Sandstone (which is about 200 m thick)].

Age: Early Permian (Roadian).

Calceolispongia rotundata Teichert

1949 *Calceolispongia rotundata* Teichert, p. 83-85, pl. 4, figs. 25-42; pl. 5, figs. 1-13.

Types: Holotype UWA 21504; paratype UWA 21505; topotypes 21506-21516, 22083, 22104, 22117-22119.

Geographic distribution: On both banks of Minilya River in N-S syncline with axis 1.3 km west of Coolkilya Pool, Minilya River, Wandagee Station, Carnarvon Basin; about 1.5 km east of Noonkanbah Homestead, Canning Basin.

Stratigraphic range: Throughout lower 50 m of Wandagee Formation, Byro Group, Carnarvon Basin; indeterminate horizon in Noonkanbah Formation, Canning Basin.

Age: Early Permian (Roadian).

Calceolispongia rubra Teichert

1949 *Calceolispongia rubra* Teichert, p. 85-89, pl. 10, figs. 11, 12; pl. 17; pl. 18, figs. 1-36, 44-47.

Types: Holotype UWA 22206; topotypes UWA 22207-22215, 22217.

Geographic distribution: In small east-west striking syncline about 500 m south of Minilya River and 800 m SE of Curdamuda Well, Wandagee Station, Carnarvon Basin; also known from other localities on Wandagee Station farther south. About 1.5 km east of Noonkanbah Homestead, Canning Basin.

Stratigraphic range: About 45-55 m above base of Wandagee Formation, Carnarvon Basin; indeterminate horizon in Noonkanbah Formation, Canning Basin.

Age: Early Permian (Artinskian, late Baigendzhinian).

Calceolispongia spectabilis Teichert

1949 *Calceolispongia spectabilis* Teichert, p. 89-92, pl. 1, fig. 9, pl. 18, figs. 37-43, 48, pl. 19; pl. 20.

Types: Holotype UWA 21519; paratypes UWA 22141a-e; topotypes UWA 22135, 22137-22140; Western Australian Museum 8486-8494; other material UWA 21517, 21518, 22136.

Geographic distribution: Syncline with N-S axis 1.3 km west of Coolkilya Pool, Minilya River, Wandagee Station, Carnarvon Basin; also in scattered localities elsewhere on Wandagee Station. Tentatively identified from unidentified locality in Noonkanbah Formation, Canning Basin.

Stratigraphic distribution: 60 to 145 m above base of Wandagee Formation, Byro Group, Carnarvon Basin. Unidentified horizon in Noonkanbah Formation, Canning Basin.

Age: Early Permian (Artinskian, late Baigendzhinian).

Calceolispongia spinosa Teichert

1949 *Calceolispongia spinosa* Teichert, p. 92-93, pl. 2, figs. 46-72.

Types: Holotype UWA 21533; paratypes and topotypes UWA 21554, 21536, (basals), 21535 (radials), 22287 (2nd brachial).

Geographic distribution: 800 m west of Callytharra Spring on One Gum Creek, 450 m upstream from its junction with the Wooramel River, Carnarvon Basin.

Stratigraphic Range: Callytharra Formation.

Age: Early Permian (latest Sakmarian, Sterlitamakian).

Calceolispongia truncata Teichert

1949 *Calceolispongia truncata* Teichert, p. 93-95, pl. 3, figs. 36-56; pl. 4, figs. 1-21.

Types: Holotype UWA 21545; topotype UWA 21546; other material 21547-21549, 21525.

Geographic distribution: Type locality on south side of Minilya River, 1 km southeast of Coolkilya Pool, Wandagee Station, Carnarvon Basin; scattered outcrops farther upstream from type locality and elsewhere on Wandagee Station.

Stratigraphic Range: About 120 m below top of Cundlego Formation, Byro Group, but vertical range not well established. In the type section, the Cundlego Formation is 332 m thick.

Age: Early Permian (Artinskian, Baigendzhinian).

Calceolispongia sp. ind. A

1949 *Calceolispongia* sp. ind. A, Teichert, p. 95-96, pl. 2, figs. 19, 20; pl. 23, figs. 13-16.

Material: UWA 21475, 21500, 21501.

Geographic distribution: In centre of syncline 1.3 km west of Coolkilya Pool, Minilya River, Wandagee Station, Carnarvon Basin; also additional scattered localities on Wandagee Station.

Stratigraphic range: Probably Nalbia Sandstone, Byro Group (associated with *Calceolispongia robusta*).

Age: Early Permian (Roadian).

Calceolispongia sp. ind. B

1949 *Calceolispongia* sp. ind. B, Teichert, p. 96, pl. 23, figs. 17-18.

Material: UWA 21498.

Geographic occurrence: Southeastern part of Wandagee Hill, Wandagee Station, Carnarvon Basin.

Stratigraphic range: Coolkilya Sandstone, Kennedy Group.

Age: Early Permian (Roadian).

Calceolispongia sp. ind. C

1949 *Calceolispongia* sp. ind. C., Teichert, p. 96, pl. 23, figs. 19-21.

Material: UWA 21499.

Geographic distribution and *stratigraphic range*: As for *Calceolispongia* sp. ind. B.

Age: Early Permian (Roadian).

Calceolispongia sp. ind. D

1949 *Calceolispongia* sp. ind. D, Teichert, p. 96-97.

Material: UWA 21502.

Geographic occurrence: Southeast limb of syncline west of Coolkilya Pool, Minilya River, Wandagee Station, Carnarvon Basin.

Stratigraphic range: Probably Baker Formation, Byro Group.

Age: Early Permian (Roadian).

Calceolispongia sp. ind. E

1949 *Calceolispongia* sp. ind. E, Teichert, p. 97, pl. 4, figs. 22-24.

Materials: UWA 215201

Geographic occurrence: Nalbia Paddock, 1800 m due east of NE corner of Mungadan Paddock, Wandagee Station, Carnarvon Basin.

Stratigraphic range: Quinnanie Shale, Byro Group.

Age: Early Permian (Artinskian, late Baigendzhinian).

Calceolispongia sp. ind. F

1949 *Calceolispongia* sp. ind. F, Teichert, p. 97, pl. 2, figs. 73-76.

Material UWA 21522.

Geographic occurrence: On east limb of Barrabiddy anticline, outcrops 400-800 m south of Barrabiddy Dam, Wandagee Station, Carnarvon Basin.

Stratigraphic range: Coyrie Formation, basal Byro Group; associated with *Calceolispongia barrabiddiensis*.

Age: Early Permian (Artinskian, early Baigendzhinian).

Calceolispongia sp. nov.

1967 *Calceolispongia* spp. nov., Dickins in Condon, p. 152.

Diagnosis: None published

Geographic distribution: Unspecified locality in southern part of Carnarvon Basin.

Stratigraphic range: Mallens Sandstone, Byro Group.

Age: Early Permian (Artinskian, early Baigendzhinian).

Calceolispongia sp.

1967 *Calceolispongia* sp., Condon, p. 35.

Diagnosis: None published

Geographic distribution: 0.6—1.25 km west of Coyango Well, Williambury Station, Carnarvon Basin (ML 6).

Stratigraphic range: Lyons Group. (This may be the oldest recorded species of Calceolispongiidae).

Age: Early Permian (Asselian).

Calceolispongia sp.

1967 *Calceolispongia* sp., Condon, p. 42.

Diagnosis: None published.

Geographic distribution: Northeastern corner of Mundarie Paddock, Middalya Station, Carnarvon Basin (MG 158).

Stratigraphic range: Lyons Group.

Age: Early Permian (Asselian).

Calceolispongia sp.

1967 *Calceolispongia*, Condon, p. 97.

Diagnosis: None published; cup and brachials reported.

Geographic distribution: 7.25 km west of Moogooree Homestead and 800 m north of road from Moogooree to Donellys Well, Carnarvon Basin (TP 323).

Stratigraphic range: Upper part of Billidee Formation, top of Wooramel Group.

Age: Early Permian (Artinskian, early Baigendzhinian).

Calceolispongia sp.

1967 *Calceolispongia*, Condon, p. 136.

Diagnosis: None published.

Geographic distribution: Unspecified locality, Carnarvon Basin.

Stratigraphic range: Mallens Sandstone, Byro Group.

Age: Early Permian (Artinskian, early Baigendzhinian).

Calceolispongia sp.

1967 *Calceolispongia* sp. Condon, p. 165.

Diagnosis: None published.

Geographic distribution: Unspecified locality in Carnarvon Basin, probably on Wandagee Station.

Stratigraphic range: Quinnanie Shale, Byro Group.

Age: Early Permian (Artinskian, late Baigendzhinian).

Calceolispongia sp.

1967 *Calceolispongia*, Condon, p. 173.

Diagnosis: None published.

Geographic occurrence: Unspecified locality on either Williambury, Middalya, or Wandagee Stations, Carnarvon Basin.

Stratigraphic range: Nalbia Sandstone, Byro Group.

Age: Early Permian (Roadian).

Calceolispongia sp. ind.

1950 *Calceolispongia* sp. ind. Guppy, Cuthbert & Lindner, p. 8, pl. 1, figs. 1-3.

Diagnosis: None published.

Geographic distribution: Northern flank of Nerrima Dome, Nerrima Station, Canning Basin (145 km southeast of Derby) (Sample N17).

Stratigraphic range: Unspecified horizon in Noonkanbah Formation.

Age: Early Permian (Artinskian, Baigendzhinian).

Jimbacrinus Teichert

Type species: *Jimbacrinus bostocki* Teichert, 1954

Diagnosis: Cup large bowl-shaped with shallow invagination below; basals very large, hexagonal, mammillate; radials pentagonal, equal, smaller than basals, separated in CD interray by anal X, radial arm facets form entire upper surface of plates, inclined outward-upward; anal X quadrangular, height equal to lateral radial facets. Individual cup plates commonly ornamented with one or more tubercles. Arms uniserial, pinnulate coiling, primibrachs 1 and 2 trapezoidal, distal brachials cuneiform. Stem small relative to cup size with alternating long and short columnals (modified after Lane in Moore & Teichert 1978 by Willink 1979, p. 181).

Remarks: Yakovlev (1964, p. 109-111) discussed *Jimbacrinus* and pointed out its similarity to *Cromyocrinus*, known from the Carboniferous and Permian of Oklahoma, Arkansas, and the Moscow Basin, and suggested transfer of *Jimbacrinus* to Cromyocrinidae, regarding the differences in morphology of the basal plates as taxonomically unimportant. However, Moore, Strimple and Lane (in Moore & Teichert 1978, p. T155) retained Teichert's systematic arrangement.

Range and distribution: Lower Permian (Artinskian) of Western Australia and Tasmania.

Jimbacrinus bostocki Teichert

1954 *Jimbacrinus bostocki* Teichert, p. 71-75, pl. 13, figs. 1-7; pl. 14, figs. 1-11.

Types: Holotype BMR[1] 326; paratypes BMR 327, 329; hypotypes BMR 330-334; additional material BMR F. 17,586.

Geographic distribution: South side of Gascoyne River, 3.5 km east of Jimba Jimba Homestead, Jimba Jimba Station, Carnarvon Basin.

Stratigraphic range: Unspecified horizon in Cundlego Formation, Byro Group.

Age: Early Permian (Artinskian, Baigendzhinian).

Jimbacrinus minilyaensis Webster

1990 *Jimbacrinus minilyaensis* Webster, p. 70-71, pl. 3, figs. 2, 3.

Types: Holotype UWA 83,763; paratype UWA 83,764.

Geographic distribution: Northeast side of syncline 1.3 km west of Coolkilya Pool (*not* east of Coolkilya Pool as stated by Webster 1990).

Stratigraphic range: Unspecified horizon in Wandagee Formation.

Age: Early Permian (Artinskian, late Baigendzhinian).

Calceolispongiidae gen. nov., sp. nov.

1956 Calceolispongidae sp. nov., Dickins and Thomas, p. 126.

Diagnosis: Closely allied to calceolispongiid plates from the Umaria beds [India], described by Reed (1928) as dermal tubercles of fish" (Dickins and Thomas, 1956). Probably based on same material as "Calceolispongidae gen. et spec. nov." of Dickins and Thomas (1959). Some of the plates described by Reed (1928) were refigured by Teichert (1949 pl. 25, figs. 19-22). Nothing like these plates has ever been described from anywhere in Western Australia.

Geographic occurrence: Unspecified locality (or localities) in southern half of Carnarvon Basin.

Stratigraphic range: Unspecified horizon in Lyons Group.

Age: Early Permian (Asselian).

[1] BMR = Bureau of Mineral Resources, Geology and Geophysics, Canberra

Calceolispongiidae gen. nov., sp. nov.

1959 Calceolispongidae gen. et sp. nov., Dickins and Thomas, p. 78.

1967 Calceolispongidae gen. et sp. nov., Condon, p. 61.

Diagnosis: None published; cup plates and columnals reported. Said to be "very close to or identical with" *Calceolispongia* sp. from Umaria, India (Dickins and Shah 1977 p. 9).

Geographic distribution: South side of Wooramel River, 800-2 400 m west of Callytharra Spring, Carnarvon Basin; also in Lyndon River area.

Stratigraphic range: Type Carrandibby Formation, uppermost Lyons Group.

Age: Early Permian (late Sakmarian).

Calceolispongiidae gen. nov.?, sp. nov.

1977 Calceolispongidae gen. et sp. nov., Dickins, Towner & Crowe, p. 277, pl. 1, fig. 1-3

Diagnosis: None published, but the illustrations show a second brachial plate, 12 mm wide, with a prominent central elevation which is 11 mm high. Said to be similar to second brachial plates described by Dickins and Thomas (1959) from the Lyons Group of the Carnarvon Basin.

Geographic distribution: Northwestern part of St. George Range, Canning Basin (BMR Locality N1206).

Stratigraphic range: Grant Group, Millajiddee Member of the Carolyn Formation.

Age: Early Permian (latest Asselian or earliest Sakmarian).

Calceolispongiidae gen. ind., sp. nov.

1967 Calceolispongidae sp. nov., Condon, p. 48.

Diagnosis: None published.

Geographic distribution: Right bank of Kialawibri Creek 2.4—3.6 km upstream from its junction with the Lyndon River, Carnarvon Basin.

Stratigraphic range: Unspecified horizon in Lyons Group.

Age: Early Permian (Asselian).

Calceolispongiidae gen. et sp. ind.

1987 Calceolispongiidae sp., Webster p. 127, Fig. 15A, B.

Description: see Webster (1987).

Geographic distribution: Right bank of Kialawibri Creek 2.4—3.6 km upstream from its junction with the Lyndon River, Carnarvon Basin.

Stratigraphic range: Unspecified horizon in Thambrong Formation, Lyons Group.

Age: Early Permian (late Sakmarian).

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